Introduction

1 Ultra-violet ('UV') cured inks, varnishes and lacquers have been in production since the early 1970s and their use is continuing to increase. The printing process uses materials which are chemically different from those used in conventional printing. Curing is effected by exposure to ultra-violet light which dries freshly printed material almost instantaneously. The process may give rise to a number of hazards. The uncured inks, varnishes and lacquers may contain constituents which are skin irritants or sensitisers or which may be harmful to the eyes; ozone may be produced by the action of the ultra-violet light on oxygen in the atmosphere of the enclosure housing the ultra-violet light source; and ultra-violet light may be harmful to the eyes whether viewed directly or on reflection.

2 The low incidence of occupational ill-health in printing workers involved in the handling and use of 'UV' cured inks, varnishes and lacquers suggests that effective protection from those hazards which may exist can be achieved by the adoption of certain basic precautions.

Description and process details

3 Ultra-violet cured inks, varnishes and lacquers are composed of liquid components which polymerise to a hard surface when exposed to high intensity ultra-violet light. Drying can be almost instantaneous but will be dependent on machine speed and the number of ultra-violet light sources used, as well as their intensity. The components are based on polyfunctional acrylate or methacrylate esters and photoinitiators such as benzo-phenone are used to cause polymerisation at the double bonds to convert the liquid to a solid. The viscosity or tack is controlled by polyacrylate esters of low viscosity and volatility which can be copolymerised with the other liquid components. Although some 'UV' cured inks used in flexographic and gravure printing may contain solvents, most 'UV' cured inks may be considered as solvent free.

4 'UV' cured inks are gaining in importance for all types of general printing and packaging applications, where their fast drying and durable film forming properties can be utilised. Typical applications for 'UV' cured inks are carton printing, labels and pharmaceutical packages, and printing of the outer surface of food and confectionery wrappers.

5 Printing of aluminium foil and foil-coated boards and other metal decorating uses are well established. Clear 'UV' cured varnishes and lacquers are used for general overprinting work; and application to record sleeves gives a protective finish approaching film lamination. Offset lithography application of 'UV' cured inks and varnishes is by conventional wet litho or dry offset processes while 'UV' cured lacquers can be applied on a press with a varnishing attachment or as a separate process using a varnishing machine. Although curing by ultra-violet light has hitherto found its primary application in lithographic printing, the same principles of protection may be applied to other processes such as silk screen printing or the production of photopolymer printing plates used by some newspapers. In the latter process purpose made machines are used to coat a metal plate with liquid polymer – acrylates and methacrylates – which is then exposed to ultra-violet light through a negative film. The uncured (unexposed) liquid resin is then removed. The plate, consisting of text etc in relief composed of hardened resin, is used for letterpress printing.

Skin contact hazards

6 These are the most pronounced hazards. Some of the polyfunctional acrylates and methacrylates can cause skin irritation and some can additionally cause skin sensitisation. The first signs of irritation – reddening of the skin and appearance of a rash – may not develop until a day after exposure, worsening over the following two to three days.

7 Skin sensitisation is a condition where a powerful allergic reaction manifests itself in people previously exposed and renders them sensitive to further contact with these materials even in minute quantities. The skin can become red and swollen, not always at the site of contact; this may occur, for example, around the eyes. Sensitised persons must be removed from any further exposure to these materials and should therefore be transferred to another job.

8 Attempts have been made on the basis of animal experiments and by patch tests on human volunteers to establish a relative hazard rating for polyacrylate and polymethacrylate materials. Amongst these is the Draize rating, derived from animal tests, which gives a measure of the primary irritant potential of a substance. It does not necessarily give its potential for sensitisation which may be provided by other tests, prominent amongst which is the Magnusson and Kligman 'guinea pig maximisation test'.

9 It should also be noted that there has recently been a move away from the Draize rating as an index for skin irritation to a rating based on test methods adopted by the Organisation for Economic Cooperation and Development (OECD) and the European Economic Community (EEC). The rating is used for chemical labelling. It is not the same as the Draize rating.

10 The Society of British Printing Ink Manufacturers (SBPIM) has recommended to its members that only materials with a Draize rating of less than 3.5 (which is less than midway on an increasing irritancy scale of 0 to 8) and with no sensitising effect, be used in 'UV' cured inks, varnishes and lacquers. A list of reactive chemicals that it was recommended should not be used was issued in 1977. The current list is reproduced in the Appendix and is continually reviewed but is not necessarily comprehensive. SBPIM members may be identified by the Society's logo on their products; other suppliers of inks, varnishes and lacquers may or may not exclude these materials. Their inclusion does not of course mean that the products in which they occur cannot be used safely. It does however mean that the precautionary measures to be adopted should reflect their presence and the increased hazards to which they may give rise.

Precautions in use – skin and eye contact

11 It is imperative that safe systems of work are adopted and adequate training given to printing workers involved in any processes using 'UV' cured inks, varnishes or lacquers to eliminate as far as possible any skin or eye contact with the uncured materials. The following precautions should be observed:

(a) powered mixing and stirring etc should take place in designated areas and be provided with suitable and effective exhaust ventilation;

(b) impervious gloves should in general be worn by machine operators or others whose work may bring them into contact with uncured inks, varnishes or lacquers;

(c) operations involving the manipulation of uncured inks, varnishes or lacquers should only be undertaken with adequate protective equipment, e.g. impervious apron, gloves, and eye protection. In particular, if in any circumstances operators are required to use reactive materials to vary, for example, the viscosity and where there is a risk of spray, the operations should be carried out in designated areas under conditions of maximum enclosure, and full protective equipment should be worn. Protective equipment in this case includes impervious apron (including a bib) and long gauntlet gloves, and eye protection which may suitably be provided by a clear plastic face shield. The face, neck, and forearms tend to be the more susceptible areas and should be covered as far as possible;

(d) protective equipment should be cleaned or disposed of after any obvious contamination as it may be a method of transferring uncured material. Contaminated clothing which is to be sent for laundering should be suitably labelled to draw attention to the skin contact hazard and the need to launder so as to avoid cross-contamination. Where contaminated clothing is to be disposed of it should be placed in suitable containers labelled in the same way as those containing spillage waste (see section 15). The use of disposable gloves is to be encouraged as far as possible. There is obviously a conflict between the need to protect hands by the use of gloves, and the hazard these may present by their being caught in moving rollers. As a general principle, gloves that fit well and are not too strong should be chosen. The adoption of the 'inch-stop-clean' method of cleaning sheet fed machines will also reduce the risk of trapping;

(e) operators should be fully instructed regarding the risk of transfer of uncured material to the face, eyes, or other exposed surfaces of the skin from their own gloved hands;

(f) containers for uncured inks, varnishes or lacquers, reactive materials, etc should be kept closed when not in use;

(g) the cleaning of machines and associated equipment, troughs, rollers, etc is carried out by operators regularly, for example at change of colour, end of shift or the working day, or change to other inks. The following precautions should be observed when cleaning operations are undertaken:

(i) adequate protective clothing e.g. impervious apron and gloves should be used. It is a common practice to use rags dampened with solvent for cleaning, which then become contaminated with uncured material. Skin contact with contaminated rags is then particularly likely to be a serious cause of skin irritation owing to the 'defatting' action of the solvent and the deposition of uncured material on the unprotected skin. The cleanings rags, once used, should be disposed of immediately and not put in overall pockets or left on benches where others may handle them unwittingly;

(ii) suitable containers labelled to indicate that skin contact should be avoided should be provided for the safe disposal of contaminated rags etc;

(iii) permeable clothing which becomes accidentally splashed with cleaning solvents should be removed forthwith;

(iv) if cleaning solvents are intended to be used several times before eventual disposal, they should be kept for use only for cleaning machines etc using 'UV' cured materials, and should be stored in suitable closed containers labelled to indicate that skin contact should be avoided.

Eye protection – ultra-violet light

12 Screening should be provided and maintained to prevent direct or reflected ultra-violet light from being emitted to the workroom. No attempt should be made to inspect printed sheets under the lamp because of the high levels of reflected light; sheets should be removed from the press for inspection. If exceptionally the lamp has to be run without screening for maintenance purposes, goggles suitable for protection from ultra-violet light should be worn. Broken or damaged screens or filter glasses should be replaced. Eye protection from the uncured inks, varnishes and lacquers themselves, and the associated first aid measures, are dealt with separately in paras 11 (c) and 16.

Ozone

13 The ultra-violet light source may be substantially enclosed in the machine frame and is not always immediately apparent. Considerable heat is evolved by ultra-violet sources and in consequence mechanical extraction is usually provided for the lamp enclosure, primarily to effect air cooling but this also removes ozone which is produced by action of the ultra-violet light on the surrounding atmosphere. Air from cooling fans should therefore be ducted outside and not returned to the workroom. Tests conducted by the Health and Safety Executive in these circumstances have shown the ozone hazard to be negligible. The TLV is currently 0.1 ppm at which concentration the characteristic odour can usually be smelled.

Other hazards

14 Care should be taken not to associate incorrectly other symptoms with the use of the 'UV' cured inks, varnishes and lacquers. For example, complaints of tingling fingers may actually be attributable to a slight electrostatic charge caused by the dry paper passing over insulating rollers. Sore eyes and dry throats may be attributable to unsuitable ventilation or low humidity in the workroom. Surveys by the Health and Safety Executive indicate that there is minimal primary hazard either from ink fly or vapour emissions in these processes.

Spillages

15 Spillages of uncured inks, varnishes and lacquers, cleaning solvents etc, should be covered with suitable absorbent material such as sawdust or liquid-absorbing granules and removed for disposal in suitable containers labelled to indicate that skin contact should be avoided.

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First aid measures

16 Any contact of uncured material with the eyes should be dealt with by washing the eyes with copious amounts of water and by seeking medical assistance. Skin contact should be dealt with by washing with soap and water.

Appendix Reactive chemicals not to be included in 'UV' cured formulations as recommended by SBPIM

The Society of British Printing Ink Manufacturers has advised its members that the following reactive chemicals should not be included in 'UV' cured formulations:

2-Hydroxyethyl acrylate
2-Hydroxypropyl acrylate
Methylcarbamyl ethyl acrylate
1, 3-Butylene glycol diacrylate
Butyl glycidyl ether acrylate
1, 6-Hexanediol diacrylate
Phenyl glycidyl ether acrylate
Acrylate of glycidyl ester of C_{9-11} carboxylic acid
Neopentyl glycol diacrylate
Phenyl cellosolve acrylate
Dicyclopentenyl acrylate
2-Ethyl hexyl acrylate (2EHA)
Di ethylene glycol diacrylate
Tetra ethylene glycol diacrylate
Mixtures of pentaerythritol tri- and tetra-acrylates (PETA)

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